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AUTHOR	Meyer, Rex
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ABSTRACT

In this paper the author presents ideas of some science educators who, in their writing, have emphasized problems of re-orienting specialists for teaching unified science. The paper makes a few preliminary suggestions on how specialist teachers may be given the necessary assistance in scientific content, philosophy and teaching strategy to prepare them to teach integrated science. Suggestions are grouped under the following headings: (1) Curriculum Development, (2) Pre-Service and In-Service Training, and (3) Within-School Practice. Throughout the paper special references are made to developments in Australia where the author has been closely associated with integrated science programs for grades 7 to 10 and grades 11 and 12 in the secondary schools of New South Wales. An extensive reference and notes listing is presented with the background paper. (EB)

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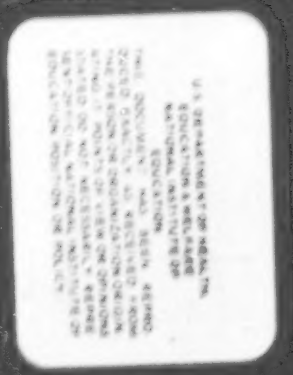

Summary of Paper Entitled

RE-ORIENTATION OF SPECIALISTS

Rex Meyer

RE-ORIENTATION REQUIRED AT THREE LEVELS

1. CONTENT
2. PHILOSOPHY
3. TEACHING STRATEGY

RE-ORIENTATION THROUGH CURRICULUM

1. WELL DEVISED COURSES
   - principles of integration stressed
2. FLEXIBLE MATERIALS
   - modules
   - multi-media approach

PRE-SERVICE TRAINING

- broad curricula
- links with specific courses
- special materials
- a cyclical problem

IN-SERVICE TRAINING

- special courses
- teachers centres
- regional counselling
- teachers' associations
- professional literature
- tests and examinations

WITHIN-SCHOOL PRACTISE

- philosophical leadership
- integration of over-all curriculum
- teaching sequences
- team teaching
- staff evaluation of teaching
- individualised self-paced programmes
- materials requiring self-evaluation by learner
- flexible classroom
- open space planning
- multi-media resource centres
- decentralised multi-media learning stations
- tape data banks
- programmed instruction
- radio and television

CONCLUSION

- the importance of curriculum evaluation
- research studies

"'Integration', when applied to science courses, means that the course is devised and presented in such a way that the student gains the concept of the fundamental unity of science; the commonality of approach to problems of a scientific nature; and is helped to gain an understanding of the role and function of science in his every-day life, and the world in which he lives."

"Such a course eliminates the repetition of subject matter from the various sciences and does not recognise the traditional subject boundaries when presenting topics or themes."

J.A. d'Arbon (1972)[1]

THE RE-ORIENTATION OF SPECIALISTS FOR A ROLE IN THE TEACHING OF INTEGRATED SCIENCE

by

G.R. Meyer*

Introduction

Most science teachers have had specialised training in one or two and at most three or four specific sciences. Professional teacher training has either been given concurrently with training in scientific disciplines or else has been an "end on" post-graduate course. This professional training, however, has usually stressed philosophy and methodology relevant to the teaching of individual sciences. The dangers of the departmentalised approach to science teaching have been reviewed by Bruce Lindsay(2).

The trend towards integrated science curricula poses the problem of re-orienting these subject specialists towards the needs of the new curricula.

Re-orientation is necessary at three levels

I level of content

II level of philosophy

III level of teaching strategy

Science educators have written extensively on integrated curricula but few have emphasised problems of re-orientating specialists. The following are notable exceptions.

With regard to the level of content, studies in 1966 by Kenneth George and Susan Wrench(3) of thirty teachers of unified science in the United States suggest that success does not necessarily depend on any special or unusually distinctive previous academic preparation. Several of these teachers, however, when asked to recommend suitable backgrounds for teaching unified science stressed the need for college preparation in a number of science areas.

At the level of philosophy, the study by George and Wrench showed that some teachers of unified science would recommend training that included the history and philosophy of science; the principles of integration and the role of mathematics in science. These teachers also placed special stress on the need for appropriate attitudes : enthusiasm for the idea of unified science,

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* The Director, Centre for Advancement of Teaching, School of Education, Macquarie University, North Ryde. N.S.W. 2113. Australia.

and willingness to work and attempt new ventures.

The importance of attitude is supported by Victor Showalter (1967)[4] who writes as follows.

> "Finding teachers to teach unified science depends on finding individuals with a positive attitude rather than someone that has had college courses in all sciences. When the total staff is involved in planning the unified science curriculum, each staff member develops the needed positive attitude."

Other strategies have been suggested. Wilber Slawson[5], in a plea for an integrated programme based on the conceptual schemes of science, suggests that team teaching, non-graded classes and individualised instruction can make contributions to the success of such programmes. Most authors agree that successful integration should emphasise the processes of science and that inquiry-oriented strategies are therefore to be promoted in the classroom[6].

Other suggestions by science educators are reviewed in the main part of this paper.

In order to re-orient a specialist for a role in the teaching of integrated science we should have a clear idea of the special characteristics desired of such a teacher. For a discussion of these characteristics refer to the paper by Victor Showalter given at Session P2 of this Conference.

This present paper assumes these characteristics. It makes a few preliminary suggestions on how specialist teachers may be given the necessary assistance in scientific content, philosophy and teaching strategy to prepare them to teach integrated science.

Suggestions are grouped under the following headings:

A. Curriculum Development
   - i. well devised courses
   - ii. flexible curriculum materials

B. Pre-Service and In-Service Training
   - i. re-organisation of pre-service programmes
   - ii. in-service courses
   - iii. teachers' centres
   - iv. regional counselling teams
   - v. science teachers associations/professional literature
   - vi. tests and examinations

C. Within-School Practise

i. philosophical leadership and over-all curriculum

ii. programming

iii. class organisation

iv. classroom design

v. audio-visual technology

D. Summary and Conclusion

Throughout the paper special reference has been made to developments in Australia where the author has been closely associated with integrated science programmes for grades 7 to 10 and grades 11 and 12 in the secondary schools of New South Wales.

A. Curriculum Development

Probably the most effective first line of approach to re-orientation is through the official publications of curriculum projects, especially through syllabuses and learning materials.

i. Well Devised Courses

In most integrated programmes there is generally a clearly presented syllabus setting out aims, objectives, philosophy and content. This document can be of central importance for the re-orientation of the specialist.

Many programmes of integrated science that issue well organised course outlines of this type are described in the Eighth Report of the International Clearinghouse on Science and Mathematics Curricular Developments 1972[7]. Additional information on appropriate courses for the elementary school is available in a special report of the Editors of Science and Children[8]. Refer also to secondary school courses described by Hall[9], Keohane[10], Klopfer[11], Pfeiffer[12], Showalter[13] and van Deventer[14]. At the tertiary level, courses described by Gratz[15], Hudes and Moriber[16], Fensham and Fyfield[17], Picker *et al*[18] and Winthrop[19] are of special interest.

One of the most comprehensive statements of the type advocated is given in Curriculum Paper No. 7 (1969) of the Scottish Education Department - Science for General Education[20]. This publication is worthy of close study.

In Australia, integrated science programmes were introduced in New South Wales grades 7 to 10 in 1962 and grades 11 to 12 in 1966. There is a considerable literature on these courses (for example Barker *et al*[21], Bishop[22], Clark[23], Mellor[24], Meyer[25] [26], Stanhope[27] and the New South Wales Science Teachers' Association[28]. The official syllabus for integrated science for secondary grades 2 to 4 in N.S.W. is of particular interest in that it gives a detailed account of the philosophy of integration. It suggests that integration can be achieved by six main methods[29].

1. By stressing the unity of nature and convergence of science

2. By recognising and applying major concepts common to several disciplines

3. By emphasising the processes and methods of science

4. By organising content according to cross disciplinary topics or themes

5. By stressing the history of science

6. By choosing topics stressing interdependence of sciences

Each method is discussed in some detail. This elaborate rationale was a major factor in the successful introduction of the course in New South Wales over a period of only twelve months (1962 to 1963), without pre-trialling or massive in-service preparation. (Meyer[30]).

ii. Flexible Curriculum Materials

Science teachers, like pupil learners, proceed most confidently from the more familiar to the less familiar. Teachers previously trained as subject specialists are therefore most likely to succeed in integrated science if learning materials are presented in small units or modules, some of which contain subject matter relating to one discipline, others being interdisciplinary in emphasis. (The concept of the module is discussed at some length in publication 31 of the Commission on Undergraduate Education in the Biological Sciences[31]). An extension of the modular concept is to include with each unit, practical activities, audio-visual materials and tests (see Meyer[32]). Modules of this type virtually become micro- or mini- courses (Postlethwait and Russell[33]), with self contained objectives, philosophy, content and strategies. Provided all elements within the module, while conceptually related, can also stand alone, teachers can build teaching sequences and integrate subject matter with almost infinite variety.

Two Australian projects that have successfully used multi-media modules are the Australian Science Education Project (ASEP) and the National Science Curriculum Materials Project (NSCM). Both are briefly described in the Eighth Report of the International Clearinghouse[34]. These projects promise to contribute a great deal to the ready acceptance of an integrated philosophy by subject specialists in Australian schools.

B. Pre-Service and In-Service Training

With the trend towards integrated courses now well in evidence, many teacher education institutions are now developing special programmes. Teachers with specialised training are being re-oriented through various in-service activities.

i. Re-organisation of Pre-service Programmes

In Australia, state-wide school systems have, in recent years changed to integrated science, especially in grades 7 to 10. Many science teachers, however, still tend to study specialised sciences in university courses and then require re-orientation during a post-graduate year of professional training. At Monash University in Melbourne, during the professional year, all students take a science core, stressing integration, and in addition at least one of chemistry, physics, biology or junior secondary science. (Fensham and Fyfield[35]). At

William Balmain College in Sydney, training programmes are modified according to the academic background of the student teacher. Those training for integrated programmes in forms 1 to 4 are required to take special topics from the integrated syllabus to "make good" deficiencies in academic training. The biology majors are required to concentrate on geology with some physics and chemistry. Physical science students concentrate on biology with a little geology and mathematics majors take a little from each branch of science. (Clark[36]). Both the Monash and William Balmain programmes consider philosophy and teaching strategy as well as content.

Such pre-service programmes are especially successful if linked to a specific integrated curriculum, operating within the relevant school system. Some integrated programmes in the United States - for example the Intermediate Science Curriculum Project (ISCS) - have produced special material for teacher education[37]. These ISCS materials appear to be remarkably successful in achieving rapid orientation of teachers in training[38].

The problem of integration is in part cyclical. The graduates from integrated science programmes in secondary schools will be receptive to integrated programmes in tertiary institutions - at that point the problem of re-orientation disappears. Bishop[39], suggests ten years from the first introduction of integrated courses in secondary schools would be required to achieve this objective. This cycle can also be broken at tertiary institutions. Anders[40] recommended as early as 1959, that in Australia, universities should introduce broader based academic programmes in science, especially for teachers of science. This has since been achieved in many tertiary institutions and this trend has accelerated the acceptance of integrated programmes in Australian schools.

ii. In-service Courses

"It is increasingly recognised that one of the best ways to improve teaching and learning in science is to plan for the continuous up-grading of teachers and teacher-trainees through in-service training." (Baez 1967[41]). This principle is of special relevance at the present stage in the development of integrated science since the majority of science teachers are specialists requiring re-orientation. The report of the I.C.S.U. Congress at Droujba in September 1968 stressed the need for both scientific and educational retraining of teachers[42].

Summer schools and vacation courses conducted by universities and teacher education colleges are well established methods of in-service. Experience in New South Wales suggests that these types of courses can readily close the gap in teacher preparation at the level of content but are less successful at the levels of philosophy and teaching strategy, although they can help with training in routine techniques. (Meyer[43]).

What is required for complete re-orientation is systematic regular retraining. Morgan [44] reports that in Japan every science teacher is expected to attend a Science Education Centre once every five to seven years. The teachers attend full-time for six months on full pay and are instructed in content and method.

iii. Teachers' Centres

Area centres for science teachers providing longer-term retraining courses seem to be effective in Japan. In the United States, however, a study by White, Raun and Butts[45] suggests that attendance at such centres should be more closely integrated with the school programme. These workers found that meetings at area centres for eleven half-day sessions throughout the school year provided excellent opportunities for the re-orientation required for new curricula in science.

Teachers' centres are now being established in many countries (e.g. Meyer[46]), and could provide a major contribution in retraining specialists for teaching integrated programmes. Lewis[47] stresses the special importance of such centres in developing countries and recommends staffing by curriculum-training-research teams.

vi. Regional Counselling Teams

Most school systems employ inspectors or consultants or advisers who visit schools for discussions with teaching staff. In many countries these people have been, in the main, concerned with matters such as promotion and regrading of staff. In recent years, however, the trend has been towards professional consultancy. In Australia this trend has fortunately coincided with the move towards teaching integrated science. Science consultants in several of the Australian states have been especially helpful in the re-orientation of specialists through individual counselling and by exchanging information between schools (Mayfield[48] and Macdonald[49]). Australian experience has suggested that such consultants are most effective when based at regional teachers' centres rather than at head office in the capital city.

v. Science Teachers Associations/Professional Literature

Professional associations of science teachers can be powerful agencies for change. Meyer has reported active curriculum involvement by such associations in Tanzania and Zambia[50] [51]. Such associations can, however, be agencies of conservatism. Specialist science teachers are usually apprehensive about changing over to integrated programmes. Many also remember with concern failures of earlier curricula in general science (for example see Connell and James[52] and Keeves[53]). Surveys conducted by the Science Teachers Association of New South Wales in 1963 and reported by Hukins[54] showed strong opposition by the Association to integrated science programmes for grades 11 and 12. Such opposition can be overcome by involving teachers in the process of curriculum development. In Australia both ASEP and NSCM have reported dramatic changes in the attitudes of teachers involved in writing workshops. (Ramsay and Slattery[55]). Involvement in the production of integrated curriculum materials appears to be a key to this problem. Once convinced of the need for integrated programmes professional associations can help in re-orientation by mounting conferences, seminars and workshops; and by participating in curriculum development, especially by writing and trialling new integrated learning materials.

Specialist teachers, with many years of teaching experience, can at times be relatively conservative due merely to lack of information about current trends. Professional associations and school systems can help in re-orientation through the production and dissemination of interesting relevant literature on the concept of integrated science[56].

vi. Tests and Examinations

All teachers who have prepared candidates for public examinations set by centrally organised school systems, understand what a powerful influence these have had on teacher attitude. While few educators would give unqualified support for centrally controlled public examinations, they are aware that they can be usef as instruments of curriculum change. Public Examinations for the School Certificate[57] and Examiners Reports[58] published by the N.S.W. Department of Education in 1965 and 1966 greatly assisted in the re-orientation of specialist teachers for the new integrated courses being implemented in that state.

In addition, self evaluative tests built into curriculum materials such as ASEP, ISCS and NSCM have had the dual role of testing attainment, and providing teachers with some insight into important educational objectives (also see Cull, *et al*[59]). Such tests should be a major feature of integrated learning materials.

C. Within-School Practise

Perhaps most effective re-orientation is achieved by policies initiated and implemented within the school or college.

i. Philosophical Leadership and Over-all Curriculum

Re-orientation will be most successful in schools and colleges with innovative and dynamic administration. Experiments with total integration of the curriculum[60] or with an open school approach[61] could produce a school climate that would help to win over the subject specialist to an integrated programme. Curriculum planners in integrated science should therefore work as closely as possible with decision-makers in schools, that is with principals, supervisors of science staff and other administrators.

ii. Programming

The teaching sequence or teaching programme can be of vital importance in re-orientation. With more structured programmes such as Project Physics[62] this is determined by the curriculum makers. On the other hand, flexible learning resources such as those produced by ASEP or NSCM, leave the sequencing or programming to individual teachers. In many schools (for example those in New South Wales) the teaching programme is determined by the supervisor or master-in-charge of the science staff. In such cases imaginative programming emphasising the principles of integration can assist in re-orienting more conservative teachers.

In New South Wales, introduction of integrated curricula led to a number of published teaching sequences. Accompanied by appropriate counselling and advice from science supervisors, such programmes proved to be valuable in re-orienting attitude and approach to integration. (See especially Cullen[62], Maclay[63], Wessen[64] and Mulherin[65]).

iii. Class Organisation

Many schools and colleges with programmes of integrated science have advocated team teaching. This is particularly the case for courses at tertiary

level. Fuller[66] claims that in college courses for non-science majors the team teaching approach seems to be particularly successful for intensive courses of around six semester hours in one term. In the case of courses for science majors, however, Fuller[67] suggests that an integrated course of physics with chemistry can best be taught by one instructor provided chemistry and physics' specialists maintain regular dialogue. Grata[68] and Rhodes and Moriber[69] describe the value of teams in evaluation of integrated courses, with teaching staff from various science departments attending lectures or laboratory classes given by other members of staff to evaluate the extent to which integration is achieved in practice. Observing lessons by colleagues could be a most effective way of encouraging orientation towards the ideals of integration. (For further comment on advantages of team teaching in science also see Bishop[70]).

Some educators, however, believe that integration is best achieved if the whole programme is taught by one teacher. (e.g. Klopfer[71]). Experience in New South Wales suggests that this viewpoint is especially true for integrated courses in grades K - 10. The science course in New South Wales for grades 7 to 10 in each class is taken by one teacher who personally integrates through his approach to the subject matter (Barker *et al*[72]).

Re-orientation of the specialist can be attained by either team teaching or individual teaching. Team teaching has the obvious advantages of on-the-spot interchange of ideas but could perhaps allow the specialist to remain a specialist, dependent on colleagues for content required for a totally integrated approach. Individual teaching, provided it is backed by co-operative staff counselling, may well lead to more rapid re-orientation.

While little evidence is available on the issue it would seem probable that re-orientation of the specialist would be more successful where the pattern of classroom management remains flexible. It is probably not without significance that successful integrated programmes such as ISCS, ASEP and NSCM have produced materials for individualised, self-paced and self-evaluated learning. Flexibility in classroom organisation correlates with flexibility in curriculum and it would seem that this would make it easier for the specialist to change over to an integrated approach.

iv. Classroom Design

Teaching environment is important in re-orientation. Subject rooms such as physics or biology laboratories reinforce specialists in their subject orientation. Morris Lerner[73] has described a science laboratory for a course in integrated physics and chemistry at Barrington High School, Newark, New Jersey. The teaching room is a combination classroom and laboratory with perimeter tables designed to handle the combined course.

In New South Wales all science laboratories in government schools installed since the change over to integrated courses are designed along these lines[74] and older "specialised" laboratories have been converted to multi-purpose science rooms.

An extension of this integrated classroom is the move to develop an integrated school through open space planning[75].

Flexible classrooms lead to flexible teaching and assist in re-orientation of the specialist.

v. Audio-Visual Technology

The advantage of multi-media science learning materials has been mentioned above (section A ii). A within-school response is required if multi-media

materials are to play an effective role. Re-orientation of the specialist is likely to be achieved most rapidly in schools with flexible and innovative attitudes towards learning resources. Media resource centres, equipped and staffed to the standards of the American Library Association[76] and linked to well organised decentralised learning stations throughout the school (see Meyer[77], should stimulate innovation. The staff of the media centre can help in the transition from specialist teacher to teacher of integrated science through appropriate curriculum consultancy and by help with the selection and production of multi-media resources. Pfeiffer[78] claims that success of the integrated science course at Monona Grove High School Wisconsin, was due in part, to the development of individualised multi-media learning carrels in a newly developed resource centre in the school. (Also see Meyer[79]).

Bruce Lindsay[80] has claimed that audio-visual materials can help close the gap in the specialist teachers' knowledge of integrated science. As an example, he advocates the preparation and wide dissemination of taped lectures by distinguished experts. He also stresses the useful role of programmed instruction in closing the knowledge gap. A general review of the role of educational technology in the professional training of science teachers has been prepared by Perlberg[81] and this reference should not be overlooked in the context of re-orienting the subject specialist.

The role of mass media, especially radio and television, should also be considered as powerful agents for innovation in science teaching. Meyer[82], for example, has described the use of television in science education in Mauritius. To be effective, radio and television require well organised within-school systems. Good integrated science programmes broadcast through radio and television should have considerable influence on the attitude of the specialist teacher. Radio and television are especially effective if science teachers are personally involved in the development and production of programmes. Within-school systems involving audio and closed circuit or cassette TV can be equally, perhaps even more effective, in this regard.

Summary and Conclusion

The re-orientation of specialists for teaching integrated science is required at levels of content, philosophy and teaching strategy. This can be achieved through development of appropriate curriculum materials, by changes in pre-service and in-service programmes and by innovative policies within the school. A number of useful suggestions on pre-service and in-service training of teachers related to the problem of orientation of the specialist is contained in the report of the regional workshop on integrated science teaching in the Asian region, (Unesco[83]) held in Manila 1970.

One final point. Science teachers, by the nature of their training, are willing to be convinced by evidence. Re-orientation will be assisted by availability of data on the relative effectiveness of integrated programmes. Integrated curricula should by systematically evaluated using methods advocated by Cohen[84]. Studies by Richardson and Showalter[85] and by Slesnick[86] have been of particular importance in this regard. Further such research studies should be given highest priority.

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